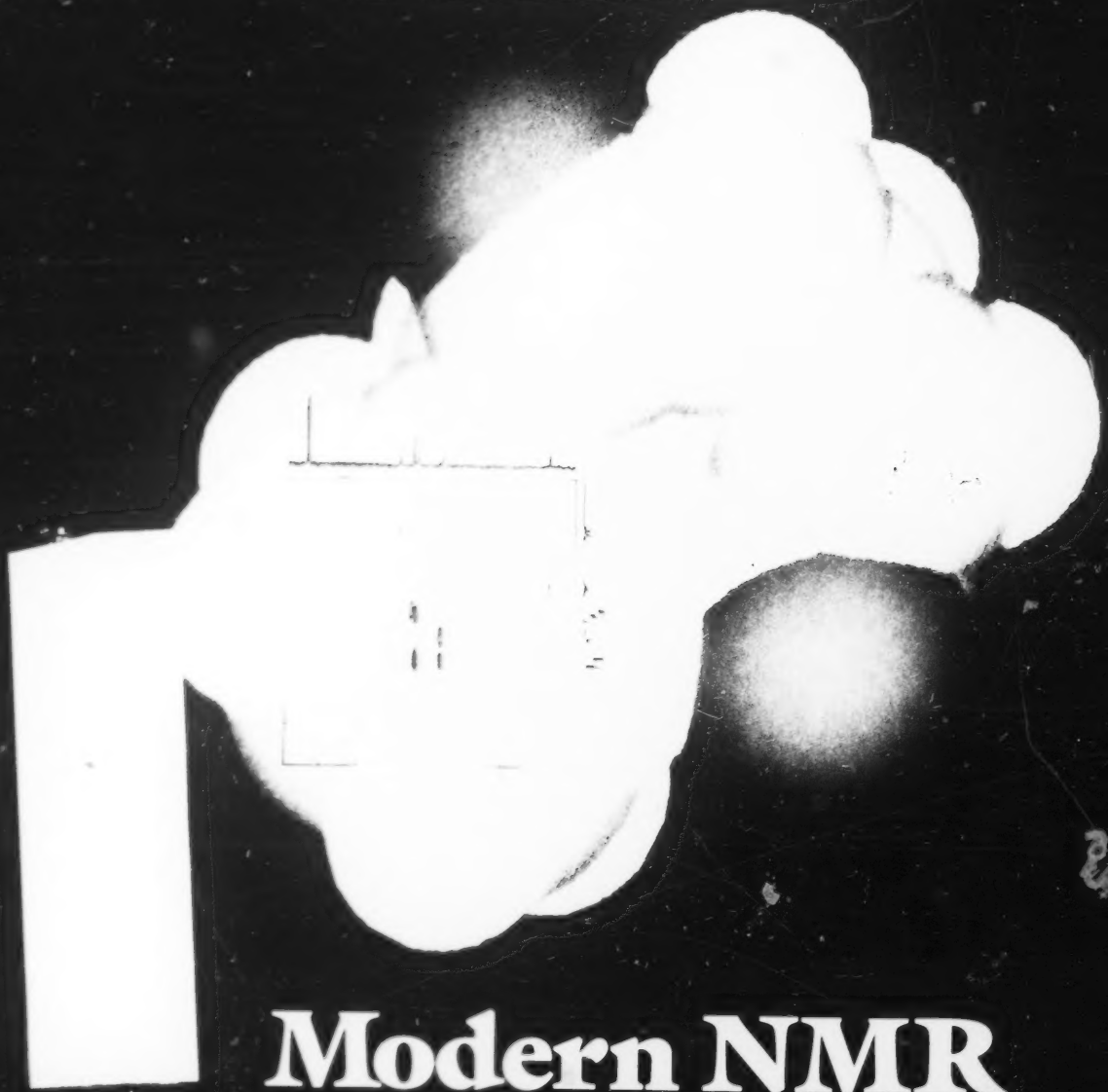
NOVEMBER 5, 1984
CHEMICAL & ENGINEERING

Thermosets' recent growth is slowing
*A Key Polymers Review*
Page 10

# NEWS



# Modern NMR Spectroscopy

**Biochemical, polymer problems yielding to new approaches** **Page 26**

CHEMICAL & ENGINEERING
NEWS

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NOVEMBER 5, 1984

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■ **Research teams at Princeton and Lawrence Livermore Lab make major advances in development of x-ray lasers.** **Page 5**

■ **An eleventh-hour agreement may save Montreal's petrochemical industry.** **Page 5**

■ **OPEC's efforts to limit production likely will have little effect on feedstock prices.** **Page 6**

■ **C&EN reporter wins Science-in-Society Journalism Award for yellow rain coverage.** **Page 6**

■ **Research park is established to develop technologies for "basic" industries such as autos, metals, and construction.** **Page 6**

*Cover:* Computer-generated space-filling model of *exo*-tetracyclo[5.5.1.$0^{2,6}$.$0^{10,13}$]-tridecane-4,8,12-trione, prepared by Richard J. Feldmann of the National Institutes of Health. The compound's $^{1}H$-$^{13}C$-correlated NMR spectrum obtained at AT&T Bell Laboratories is superimposed

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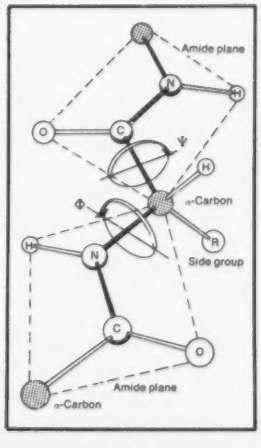



## Cover Story

**Important structural information of polymers, as well as natural products, peptide hormones, and proteins, is being obtained from advances in NMR spectroscopy.** **Page 26**

# Thermoset Plastics: Output On Rise, But Likely To Slow

**Production of phenolics, polyesters, and epoxides is forecast to grow into 1985 and then slow, pulling down growth rates to zero to 5%**

**Bruce F. Greek,** C&EN Houston

It's a heady time for producers of three major thermoset plastics—phenolics, polyesters, and epoxies. This year's production of all three resins is running well ahead of 1983 production, and well above recession lows. And prospects are good that these gains will continue into 1985, but at much slower rates.

Producers are braced for the eventuality of a slowdown. For five years after 1978, production of these thermoset resins followed a major dip that left producers with a substantial decline in output. A similar situation could begin in 1985 unless all kinds of construction grow again at the high rates of the 1970s. Fortunately, as experts see it, the coming dips in resin production won't be as large as they were in the 1980–82 era. But they will pull down average growth rates over the next five years to between zero and 5%.

Analysts have said that describing the thermoset market is like describing the economy, since thermoset resins probably follow the economy as closely as any other chemical product group. The reason is that the big consumers of thermosets are the highly cyclical construction and durable goods markets that do much to drive the economy. Construction uses more than 50% of thermoset output.

## Key Polymers

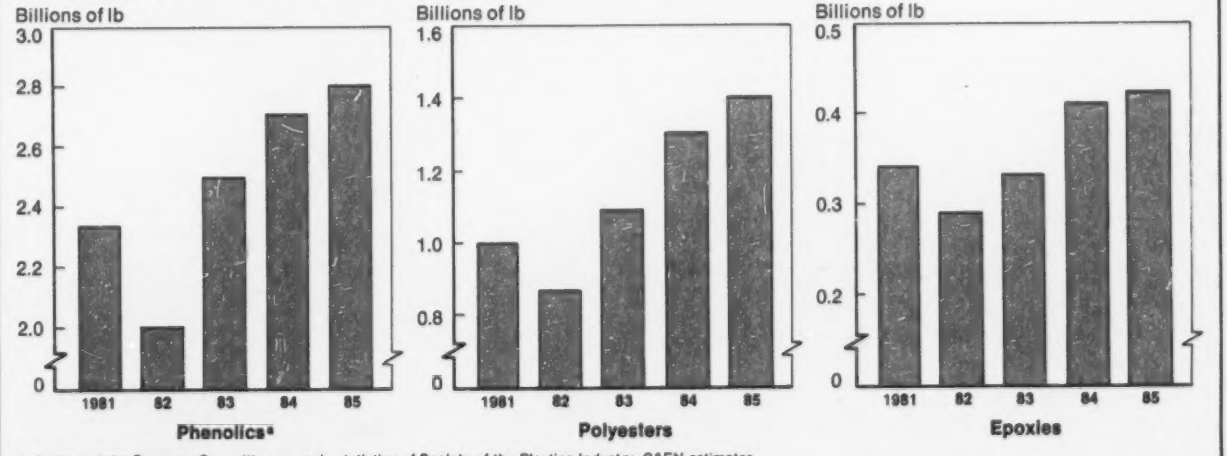
Unless an unlikely situation were to develop in which demand for these resins moved away from durable goods to nondurable goods, production will cycle from high to low levels and back again. Now that the economy is on the up side, the thermoset cycle also is on the up side, with production achieving new highs that will carry on into the first half of next year.

A shift in demand to a big nondurable use such as packaging—an end use that helps polyethylene avoid violent swings in demand—doesn't even seem to be in the cards for thermosets, since for most nondurables, price is more important than performance, and performance is thermosets' strong suit. In fact, for most uses, the thermoset plastics are the preferred product for performance reasons.

This apparent lack of new market potential has become another characteristic of thermosets as well as that of many other chemicals. Even epoxies and polyesters, youngsters compared to phenolic resins, are considered mature products.

For a more detailed account of the three major thermoset resins, see the following pages.

**Phenolics, polyesters, epoxies recovered dramatically from recession**

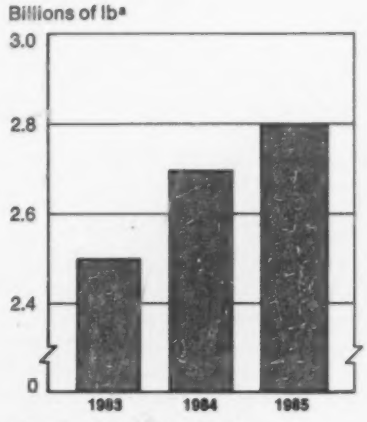



a Gross weight. **Sources:** Committee on resin statistics of Society of the Plastics Industry, C&EN estimates

# Phenolics

- ***Demand higher***
- ***Capacity on hold***
- ***Prices down***

## PRODUCTION




a Gross weight, including solvents.

## TOP FIVE PRODUCERS

*Borden Chemical, Georgia Pacific, Monsanto, Owens-Corning Fiberglas, Reichhold Chemicals*

## HOW MADE

*Reaction of phenol (or substituted phenols) with formaldehyde, subsequently cured by heat or with a crosslinking agent*

## MAJOR END USES

*Plywood adhesives 50%, insulation adhesives 15%, molded items 10%*

## FOREIGN TRADE

*Exports—small, but rising to 30 million to 40 million lb in 1984, imports—negligible*

## PRICES

*List prices vary; bulk of merchant sales in 35 to 45 cents per-lb range*

Phenolic resins are topping out another growth spurt. Annual output records for these resins again will be set in 1984 and 1985 unless a serious downturn in the economy occurs within a year. But the rate of growth expected in 1985 will be half that of 1984.

Production of the various types of phenolic resins likely will top 2.7 billion lb in 1984, up at least 8% from 1983 output. That production gain for this year will not be nearly as large as last year's almost 25% gain, when housing recovered from the recession and demand for plywood jumped.

With slowdowns in housing and other construction now appearing, the gain in production of phenolic resins during 1985 will slow to 3 to 5%, unless interest rates rise far more than expected. Thus, 1985 output of these resins could do well to reach 2.8 billion lb. (All estimates of production of phenolic resins are on a gross weight basis that includes solvents and fillers.)

Because so many different kinds of phenolic resins are made by many large and small producers, it is meaningless to estimate capacity to make these resins. Some of the capacity also can be used part time to make other resins, such as alkyds. Likewise, kettles used to make other resins also may be used from time to time to make phenolics.

In general, production of phenolic resins continues to shift toward the large producers. Small consumers who once made their own resins are more likely to buy resins and to scrap their own resin units. Development work on special resins is done mainly by the large producers. This makes them ever more competitive, which tends to force out small producers.

Operating rates for phenolic resins seldom are as good a measure of the health of this segment of the plastics industry. A sizable part of production of phenolic resins is captive, especially that going to make plywood, fiber and granulated-wood boards, and insulation. Many of the small producers operate their plants only when demand calls for it.

A big part of phenolic resins production, probably more than 75%, eventually ends up in the construction industry, with 50% going into plywood alone. As the construction industry is controlled by the general level of the economy, so is phenolic resin production. The strong upturn in housing that began in 1983 spurred demand for plywood, and phenolic resin production followed. As might be expected, inventory building in plywood surged during the second quarter of 1984 when housing starts topped out. As housing has slowed, along with industrial and other construction, efforts have begun to reduce inventories. This inventory reduction, which is still continuing, is causing production to slow.

In a similar fashion, another large construction use of phenolic resins, insulation, is slowing. Demand for insulation made, for example, of glass fiber bound with phenolic resin as an adhesive actually may be picking up at the retail level, but factory production is slowing because of the lead time. This then slows resin use seasonally. An increase in resin demand for insulation use could occur early in 1985 as producers prepare for the upturn in spring housing construction.

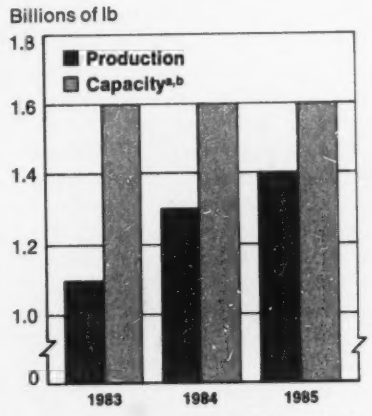
Phenolic molding compounds are the major nonconstruction use of phenolic resins. Good physical properties of strength and heat resistance plus moderate cost keep phenolic resins in long-standing uses in transportation, appliance, and electrical component markets. Growth may be small for phenolic molded items, but competition from other resins seems to be minor, so phenolics producers expect to hold on to these uses.

As one of the oldest synthetic polymers, phenolic resins continue to maintain a growth position, although sometimes erratic. Prospects for increased production are good for all of 1984 and fair in 1985.

# Polyesters

- ***Demand increases***
- ***Capacity stable***
- ***Prices up slightly***

## PRODUCTION/CAPACITY




a First quarter. b Some capacity may be used for other resins.

## TOP FIVE PRODUCERS

*Alpha Resin, Ashland Chemical, Koppers, Reichhold Chemicals, USS Chemicals*

## HOW MADE

*Mainly polyestrification of maleic and phthalic anhydrides and propylene glycol*

## MAJOR END USES

*Construction components 30%, boats and marine products 20%, cast products 10%, transportation equipment 10%*

## FOREIGN TRADE

*Exports—tiny, may reach 10 million lb in 1984, imports—negligible*

## PRICES

*List prices range from 50 to 60 cents per lb for major volume types*

Production of polyester resins in 1984 will post a strong 20% or more gain over 1983, following a pattern reestablished last year. Prospects next year for these resins—more formally called unsaturated polyester resins to distinguish them from other polyester resins used in making fibers, films, and bottles—are about in line with those for many other thermoset plastics. That means output growth of no more than half that expected for 1984.

Production this year likely will total about 1.3 billion lb, up substantially from less than 1.1 billion lb in 1983. This year's production will exceed the previous record production of 1.2 billion lb set back in 1978 and will be a very significant increase from the recent historical low of 850 million lb in 1982. And as long as the economy remains reasonably healthy, the near-term outlook for unsaturated polyester resins will be for a 4 to 6% production gain annually.

Capacity to make unsaturated polyester resins has been on hold for quite some time. As is the case with some other thermoset resins, estimates of plant capacity are not firm. Depending on demand, polyester resin facilities can be used to make other resins. Some small producers readily enter and exit production as they encounter internal or external demand peculiar to their own situations. The types of product resins made also can affect capacity to some degree.

A best-guess estimate for capacity to make polyester resins holds at about 1.6 billion lb a year. This total could be as much as 10% low during times of high demand and 20% high when demand falls drastically, as it did during the early 1980s. Because of relatively simple equipment required for manufacture, capacity additions that go beyond shifting equipment used in making other resins could be made in relatively short times.

For this year and next, capacity utilization for these resins will be quite high if compared to operations of two years ago. In fact, production could close in on the practical limits of capacity. However, even in 1985 capacity will not be pushed all-out because of the flexibility in getting additional production from other equipment.

The strong production recovery, although it's now slackening some for both economic and seasonal reasons, naturally has helped producer economics. But even though the strong demand has led to some actual increases in selling prices, downward pressure on prices has been applied because of declines in raw material prices, which many consumers expect to be passed on to them.

The production recovery ties in very closely to the economic recovery. Major uses of these resins depend on industries strongly influenced by economic conditions—construction and consumer luxuries such as boats and other recreational items. When these consumption areas feel a recession such as that of the early 1980s, unsaturated polyester resin demand falls precipitiously.

With both home and industrial construction now slowing, gains in demand for these resins in such end products as bathroom fixtures and corrosion-resistant tanks will become much smaller next year. Unless another major recession should develop, a decline in demand in these uses seems unlikely.

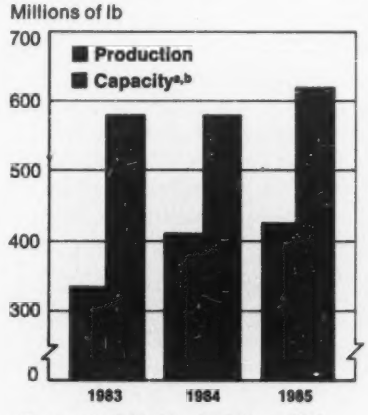
Generally used with some kind of reinforcing material such as glass fiber to overcome a problem of brittleness, polyester resins go into products that are both cost- and performance-competitive with those made with other materials. For example, polyester-glass fiber composites have almost entirely replaced wood in small boats and now are moving in on aluminum.

A host of other uses, many in the luxury products area, pushes demand for these resins in good times. But this demand quickly melts away during recessions.

# Epoxies

- ***Demand up***
- ***Capacity expanded***
- ***Prices rising***

## PRODUCTION/CAPACITY




a First quarter. b Liquid and solid unmodified resins.

## TOP FIVE PRODUCERS

*Celanese Specialty Resins, Ciba-Geigy, Dow Chemical, Reichhold Chemicals, Shell Chemical*

## HOW MADE

*Mainly reaction of bisphenol A and epichlorohydrin; modifications are made later depending on use*

## MAJOR END USES

*Coatings 45%, laminates and composites 25%, castings and molded items 10%*

## FOREIGN TRADE

*Exports—rising to more than 40 million lb in 1984, imports—increasing to more than 10 million lb*

## PRICES

*List prices range from $1.25 to $1.40 per lb for large-volume grades*

Of the three major-volume thermoset plastics, epoxy resins are setting the best pace this year. Almost all significant end uses are expanding as a result of the better economic climate. But these rosy conditions are tempered by the expectation that the present good times won't last.

Production of the various kinds of epoxy resins in 1984 will be up about 20% to more than 400 million lb, topping the previous production high set in 1979 and finally exceeding the 400 million-lb mark.

While production has been rising, so also has capacity to make epoxy resins. This year Ciba-Geigy completed at mid-year its new plant at Mcintosh, Ala., adding about 90 million lb of capacity. Part of the addition is offset, however, by a reduction in capacity at another location.

Capacity might appear to be excessive even with a substantial gain in production this year. But in most cases, capacity estimates are overstated because they include total capacity to make the various forms of the basic epoxy resin. Actual capacities also vary during the year as units may be changed to make different types of resins. Average annual capacity could be as much as 25% less than the total estimated nameplate capacity.

Thus, if production of all kinds of epoxy resins reaches 410 million lb this year, and actual capacity available for production falls somewhere in the range of 425 million to 450 million lb, then capacity utilization would be quite high. Probably a good estimate for the 1984 operating rate would be about 90% of capacity.

The current strong demand for epoxy resins has led to some price rises, both list and actual, during this year. Part of the increases were the usual pass-along price increases for raw materials. However, the increases have been quite modest relative to actual selling prices. Therefore, producers are probably not gaining any real relief in improving their profitability.

In addition, producers are concerned about future prices. If the economy slows in 1985, and demand for epoxy resins slips, then prices might weaken again. One key to holding prices would be a further shift in demand toward the electronic and electrical areas, both of which are growing faster than the old-line coating areas.

Unfortunately, coatings account for nearly half of U.S. epoxy resins consumption. Coatings are dominated by some very large uses—beverage can inside coatings, automotive primers, and industrial maintenance coatings. Each of these major uses, plus some of the smaller uses such as marine and appliance coatings, is heavily dependent on the economy. Some developmental work, particularly in automotive primer systems, could lead to some growth even in a slower economy through capture of markets from other coating materials. Longer term, any increased shift from metal beverage cans to plastic bottles, mostly polyester, could reduce this use, which now accounts for about 20% of epoxy coatings consumption.

Another quarter of epoxy resins consumption goes into various kinds of fiber-reinforced laminates and composites. Most important and fastest growing of these uses is printed circuit boards. This area seems somewhat recession-proof because of growth in demand for various kinds of computer systems, electronic toys, and the like. Although epoxy growth forecasts for these markets vary widely, it generally is forecast at two or three times greater than average growth expected for all epoxy resin uses.

Many other uses of epoxy resins are growing well, but from very small bases. There are so many small uses in this miscellaneous category that they account for more than 10% of total consumption. These uses will help pull along epoxy resin demand, but the near-term growth rate will be 4 to 5% a year because of the huge share of the resins going into various coatings.

# European Petrochemical Producers Face More Modest Growth

**Next trough may be in 1986, BP executive warns; firms should opt out of weaker lines, concentrate their efforts on smaller number of products**

"With improved [chemical company] results in 1983 and 1984, some people already are talking happily of the light at the end of the tunnel," comments Ray R. Knowland, managing director of London-based BP Chemicals International. "My thought is, 'Beware of the headlights of the oncoming train.'

"Most will agree that we are going through a peak in the chemical cycle. The next trough, perhaps in 1986, is likely to coincide with the arrival on the petrochemical scene of a number of new producers with real competitive advantages. Decisions must be made before the next recession causes financial mayhem for us all. It is vital that we look beyond the immediate prospect and plan for a profitable industry in the 1990s."

In a hard-hitting talk presented to the European Chemical Marketing Research Association's annual meeting held this year in Amsterdam, Knowland urged his fellow West European managers to follow three basic principles. "Forget about the past, think about the future; forget about weaknesses, think about strengths; forget about short-term gains, think about long-term profit," he suggests.

"Lack of lateral thinking is probably the greatest shortcoming of our industry in Western Europe today," he contends. "Some of the important things we should consider when developing a strategy for the future must include the discarding of outdated ways of thinking no longer relevant to the problems of today. Above all, we must continue to think about consolidation of the industry. But planning is not the whole story. The theory must be put into practice."

The basic strength of petrochemicals is that there are no new substitutes in sight. Consequently, they are not likely to suffer the problems of such basic industries as steel and timber. "Realism dictates, however, that any growth in demand will be modest at best, and slower than in the past," he warns.

In the case of ethylene, a fundamental building block of the petrochemical industry, Knowland anticipates that West European consumption will rise at an average annual rate of 0.8% between 1983 and 1990. On the basis of the 24.3 billion lb-a-year mean average consumption between 1978 and 1983, demand in 1990 likely would rise to about 25.7 billion lb. At that level, however, use would remain well below Western Europe's 1983 effective capacity of 33.2 billion lb.

The underlying growth in consumption of ethylene derivatives in Western Europe is similar to the industrial production index, although growth in ethylene demand is lower. Knowland notes that "this results from an expected decline in net exports with the advent of the new producers [in the Middle East and elsewhere], and, to a lesser extent, lower ethylene usage reflecting, for example, linear low-density polyethylene substituting for LDPE."

The prospect for propylene is more encouraging. Knowland pegs the annual average rate of growth at 2.5% from 1983 to 1990. This would raise demand to about 15.4 billion lb from the 13.0 billion lb-a-year mean of 1978 to 1983. Shortage is unlikely in light of Western Europe's effective output capacity of 18.73 billion lb for the olefin in 1983.

"The better picture for propylene," Knowland points out, "is due to higher growth of polypropylene, and, to a smaller degree, in propylene oxide with no threat from new producers. Propylene derivative growth will be dependent on the availability and price of propylene."

Knowland points up the problem that, compared with the U.S., there are too many producers of individual petrochemicals in Western Europe vying for markets of approximately the same size. In the case of acrylonitrile, for instance, the 10 European makers of the chemical have an average plant capacity of 264 million lb per year, less than half that of the four U.S. producers. More dramatic is the case of propylene oxide, in which the eight European companies in the business have an average annual output capability of

**Europe has more, smaller makers of major petrochemicals than U.S.**

| | Number of producers | Total annual capacity (billions of lb) | Average capacity per producer (millions of lb) |
|---|---|---|---|
| **Acrylonitrile** | | | |
| U.S. | 4 | 2.20 | 550 |
| Western Europe | 10 | 2.64 | 264 |
| **Low-density polyethylene** | | | |
| U.S. | 11 | 9.68 | 880 |
| Western Europe | 19 | 11.88 | 625 |
| **Polypropylene** | | | |
| U.S. | 12 | 5.28 | 440 |
| Western Europe | 17 | 5.28 | 311 |
| **Propylene oxide** | | | |
| U.S. | 2 | 2.86 | 1430 |
| Western Europe | 8 | 2.20 | 275 |

Source: BP Chemicals International

275 million lb, about one fifth that of each of the two corresponding U.S. concerns.

"The U.S. trend has been for companies to opt out of their weaker lines—Arco out of polyolefins, and Ethyl Corp. out of polyvinyl chloride are recent examples. But there are nothing like enough examples in Western Europe," he says.

Admittedly, steps have been taken by European companies to realign their product mix. BP Chemicals itself has shed its PVC activities, for instance. More recently, West Germany's Hoechst decided to lease its LDPE units to Italy's Enichem (C&EN, Aug. 27, page 8). "These precedents need to be followed again and again," Knowland stresses.

"Our target should be to reduce the disparity between us and the U.S. To bring this about must be the objective of our petrochemicals strategy for Europe. The advantages of a wide product portfolio, which could be marketed in groups together, have declined. With finite resources, it is wise after identifying our weaknesses to concentrate our efforts on a smaller number of products in which we have percieved strengths. To obtain optimum competition, we will need to see some very significant and almost inconceivable rationalization moves."

Nationalism in its many forms is an important competitive disadvantage in Western Europe, Knowland admits. "Unfortunately, politicians discovered years ago that jobs could be saved in the short term by delaying decisions. We now have a situation in which much of the chemical industry within Europe is plugged into politics. The closure of a cracker will lose a few seats in Parliament; therefore, hand out a subsidy has been the reasoning. However, the respite is short lived.

"We must make governments aware that we cannot afford to allow Europe to lag behind its competitors in terms of efficiency. The industry continues to need restructuring. This will occur only if individual companies are rigorous in their analysis of their portfolios, and are prepared to remove weak products as they are identified."

*Dermot O'Sullivan, London*

# Prospects stay dim for European ethylene oxide

One thing ethylene oxide producers in Western Europe have failed to do is make money, contends George Ewart, general manager of Imperial Chemical Industries' chemical products unit. "Unless the industry acts quickly, this difficulty will remain," he told the recent European Chemical Marketing Research Association's meeting in Amsterdam.

By his estimate, European companies have lost a cumulative total of some $1.5 billion on ethylene oxide and derivatives in the four years 1980–83. The pattern continues, even though 1984 is likely to be a peak year in the production cycle.

Nor is the near-term outlook promising. "A cyclical pattern of demand will persist, and the current trend appears to be downward," he notes. Moreover, he warns, "A revival of U.S. exports is likely in 1986 as U.S. domestic demand falls away."

At first glance, it appears strange that European ethylene oxide makers are losing money, considering the wide variety of products that the oxide's derivatives—glycol, glycol ethers, ethanolamines, and ethoxylates—go into. Included are adhesives, antifreeze and deicing fluids, detergents, explosives, inks, polyester fiber, film and bottles, and polyurethane foams.

**A cyclical pattern of demand will persist, and the current trend appears to be downward**

Ewart lays much of the blame for the poor economics on the companies themselves. "We are living with a legacy of overinvestment invariably justified on the back of an ethylene cracker. Some old plants apparently are being retained because they are a leg for supporting an olefins complex," he says. Barriers to exiting from the business "are reinforced by political and social considerations."

Last year, he notes, 12 European producers shared a combined nameplate capacity of 4.45 billion lb of the oxide, 2.84 billion lb of glycol. In the case of the oxide, the 3.06 billion lb produced in 1983 was only about half the U.S. output, which also is served by 12 companies. This means that European oxide plants operated on average at 69% of their capacity level.

Europe's 1983 glycol demand of 1.78 billion lb accounted for a mere 63% of installed capacity. Some 48% went into polyesters, 36% to the antifreeze market, and the 16% balance was converted to various derivatives. Although European demand for glycol continues, he foresees a slower pace of annual growth for its outlets in the second half of the decade compared with the first.

An added factor is the prospect of competition from Saudi Arabia. Next year, two glycol units will come on stream there with planned annual output totaling 1.1 billion lb. As much as half that could find its way to Western Europe, Ewart believes.

Looking to 1990, Ewart foresees Western European glycol demand amounting to 1.98 billion lb. Imports might supply 660 million lb of this need—perhaps 550 million lb from the Middle East, and 110 million lb from Eastern Europe, and North and South America. West European output, therefore, would drop to about 1.32 billion lb provided by plants with a combined overall nameplate capacity totaling some 1.56 billion lb. On the basis of this reasoning, European capacity would need to be reduced 1.28 billion lb, down 45% from the current level.

"The European industry has very little time to eliminate capacity surpluses, soften the impact of Middle East glycol, and develop a better-quality business for the late 1980s," he says. He proposes closure of uneconomic ethylene oxide plants, and continuing investment in research and technical effort. "Uncompetitive business should go, and go quickly," he urges.

*Dermot O'Sullivan, London*

# Congress enacts important funding bills

The 98th Congress has passed into history. It started on a high note with the enactment of a plan designed to ensure the solvency of the social security system. It ended in confusion, deadlocked on a number of important issues that now will have to be taken up by the 99th Congress that convenes next Jan. 3.

Both the House and Senate passed legislation overhauling the nation's immigration laws that included limitations on the ability of foreign students to remain in the U.S. after graduation. Both also approved amendments to the Export Administration Act, which ensures that shipment of U.S. products, including technical data, abroad will not harm national security. But despite numerous meetings, House and Senate conferees could not reach an agreement on either bill.

The House approved a multibillion-dollar expansion of the Superfund used to clean up abandoned hazardous waste sites and a renewal of the Clean Water Act that would have extended cleanup deadlines for industry discharges into waterways and mandated cleanup of toxic "hot spots." The Senate passed neither bill, although both cleared its Environment & Public Works Committee. The water bill, in fact, was cleared for floor action in 1983 but still never came up for a vote. Neither branch passed a renewal of the Clean Air Act even though its funding authorization expired in 1981. The question of what to do about acid rain proved to be too thorny to deal with in an election year, as did the question of decontrolling natural gas prices.

The 98th Congress did, however, enact a number of important bills, including a major math and science education bill, funded at $1 billion over two years, designed to help local school districts improve teaching efforts in these areas. It cleared a rewrite of the hazardous waste disposal law that bans most land disposal of liquid hazardous waste and, for the first time, requires generators of small quantities (100 to 1000 kg per month) of hazardous waste to comply with the law. It also passed a bill allowing companies to conduct joint R&D ventures without running afoul of the antitrust laws as long as certain conditions are met, including informing the Justice Department and the Federal Trade Commission of who the parties in a venture are and what its objective is.

Also enacted during the final days of the 98th Congress was a bill allowing an extension of the life of a patent for products that are regulated by the Food & Drug Administration. In addition, Congress cleared legislation that allows statutory invention recording (otherwise known as a "defensive patent"), combines the Board of Patent Appeals with the Board of Patent Interferences, and sets up a two-year study of the rights of employed inventors.

But most of Congress' attention during its last few weeks was focused on the subject of money. By Oct. 1, the start of the new fiscal year, Congress had cleared only four of the 13 regular appropriations bills. Luckily for the science community, those four bills included fiscal 1985 funding for the National Science Foundation, National Aeronautics & Space Administration, Environmental Protection Agency, and most of the Department of Energy's research programs (C&EN, July 16, page 24).

Those agencies were in the almost unbelievable position of knowing three months ahead of time just how much money they had to spend in fiscal 1985, but the other big research funding agencies, such as the Department of Defense and the Na-

## Congress generous to research in omnibus budget bill

| $ Millions | 1985 Congressional appropriation | 1985 Administration request | 1984 | % change 1984–85 |
|---|---|---|---|---|
| **Defense** | **$33,332.8** | **$36,054.2** | **$26,819.6** | **24%** |
| Tactical programs | 11,492.3 | 12,641.4 | 7,908.8 | 45 |
| Strategic programs | 8,348.3 | 8,735.1 | 7,842.7 | 6 |
| Intelligence and communications | 3,946.6 | 4,215.6 | 3,404.4 | 16 |
| Defensewide mission support | 3,600.9 | 3,814.8 | 3,235.3 | 11 |
| Technology base | 3,105.0 | 3,226.3 | 3,042.2 | 2 |
| Advanced technology development | 2,839.7 | 3,421.0 | 1,386.2 | 105 |
| **NIH** | **5,021.9** | **4,296.1** | **4,230.6** | **19** |
| Cancer | 1,183.8 | 1,077.8 | 1,083.4 | 12 |
| Heart, Lung & Blood | 805.3 | 690.8 | 674.6 | 19 |
| Arthritis, Diabetes & Digestive & Kidney Disease | 543.6 | 456.2 | 442.5 | 23 |
| General Medical Science | 482.3 | 375.4 | 366.8 | 31 |
| Neurological & Communicative Disorders & Stroke | 396.9 | 335.1 | 325.5 | 22 |
| Allergy & Infectious Diseases | 371.0 | 316.7 | 305.7 | 21 |
| Child Health & Human Development | 313.3 | 270.3 | 265.0 | 18 |
| Environmental Health Sciences | 194.8 | 173.0 | 177.8 | 9 |
| Eye | 181.7 | 154.3 | 150.8 | 20 |
| Aging | 144.5 | 114.3 | 112.3 | 29 |
| Dental Research | 109.7 | 87.2 | 84.3 | 19 |
| Research resources | 304.0 | 245.0 | 241.9 | 26 |
| **USDA** | **929.6** | **865.1** | **869.9** | **7** |
| Agricultural Research Service | 513.0 | 483.6 | 504.0 | 2 |
| Cooperative State Research Service | 284.3 | 266.8 | 247.6 | 15 |
| Forest Service Research | 120.9 | 103.1 | 108.5 | 11 |
| National Agricultural Library | 11.4 | 11.6 | 9.8 | 16 |
| **Interior** | **455.2** | **424.5** | **413.8** | **10** |
| Geological Survey | 412.2 | 382.3 | 373.4 | 10 |
| Fish & Wildlife Service R&D | 43.0 | 42.2 | 40.4 | 6 |
| **Energy** | **434.3** | **342.2** | **412.9** | **5** |
| Fossil R&D | 299.2 | 222.6 | 276.8 | 8 |
| Conservation R&D | 135.1 | 119.6 | 136.1 | −1 |
| **TOTAL** | **$40,173.8** | **$41,982.1** | **$32,746.8** | **23%** |

**Note:** All figures are estimates. **Source:** Congressional reports

tional Institutes of Health, didn't know how much they had until the day before Congress called it quits on Oct. 12. But the wait was generally worth it.

Funding for DOD's research, development, test, and evaluation activities was set at $33.3 billion, a 24% increase over fiscal 1984 and a 100% increase over fiscal 1981. The Administration had requested a 26% increase. The Senate Appropriations Committee sounded a warning that the days of large research budget increases may be coming to an end. In its report on the DOD funding bill, it noted that "this is probably the final year that a high level of RDT&E real growth can be sustained in the Congressional budget process."

However, the committee reaffirmed its continuing support for DOD's technology base modernization effort, saying that "increased investment in basic research and innovative technologies is a high RDT&E priority." Thus, the committee said it approved a high level of support for all technology base budget activities and full funding for the university research instrumentation program.

Be that as it may, overall funding for DOD's technology base programs, for which a 6% increase was requested, is up only 2% to $3.1 billion, whereas funding for advanced technology development has increased more than 100% to $2.8 billion. Both budget categories provide funding for university-based research. Funding for Air Force RDT&E activities is set at $13.4 billion, an increase of 10%; the Navy's at $9.2 billion, up 23%; the Army's at $4.3 billion, up 2%; and the defense agencies' at $4.2 billion, up 55%.

Congress was, as always, much more generous than the Administration in funding NIH, handing it a 19% increase to $5 billion, rather than the requested 1% increase. By some sleight of hand, two of the national institutes—Environmental Health Sciences and Dental Research—emerged from the conference committee on the appropriation bill with more money than was approved by either the House or the Senate. Included in the NIH funding are increases of at least $25 million for support of an additional 2000 research career awards; $3.3 million for the minority biomedical research support program; and $27 million for biomedical research support, of which some $10 million is to be used for a shared instrumentation program.

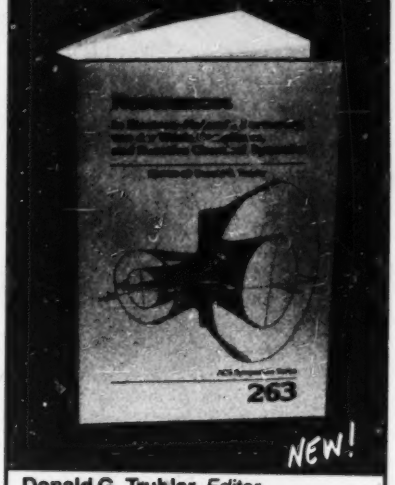
Funding for the Department of Agriculture's research programs is set at $929.6 million, a 7% increase. The Cooperative State Research Service gets the largest increase, 15% to $284.3 million. Included in that funding is the largest amount ever, $46 million, for competitive research grants—grants that have, up to now, not been well thought of by the House Appropriations Committee. Biotechnology research grants will account for $20 million, and plant science research another $16.5 million.

The Forest Service's research budget, which was slated for a 5% decrease, is up 11% to $121 million, or $18 million over the budget request. Over $5 million of the increase is to be devoted to acid deposition research, and $8 million is earmarked for a new competitive grants research program. The Agricultural Research Service gets only a 2% increase to $513 million. That amount includes $233 million for basic agricultural research and $384,000 for acid deposition research. And proving that Congress can at times move swiftly, ARS's fiscal 1985 budget includes $1 million for emergency research on citrus canker. The ARS facility in Orlando gets $250,000 and the University of Florida $750,000.

The Department of Energy's fossil R&D budget, which was slated for a 20% decrease, got instead an 8% increase from Congress, and the conservation R&D budget is down only 1% rather than the requested 12%. Included in the conservation budget is $16 million for establishment of an energy conservation applied research laboratory at Northwestern University. Finally, funding for the research programs at the Department of Interior's Fish & Wildlife Service is set at $43 million, an increase of 6%, and funding for the Geological Survey's surveys, investigations, and research programs is up 6% to $412 million.

*Janice Long, Washington*


**Resonances in Electron–Molecule Scattering, van der Waals Complexes, and Reactive Chemical Dynamics**

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